Yet Another Covid-19 year of IUCAF

Harvey Liszt

*National Radio Astronomy Observatory**

Charlottesville, VA

&

Chair, IUCAF

http://www.iucaf.org

*NRAO and GBO are operated by Associated Universities, Inc. under a cooperative agreement with the National Science Foundation

Topics from IUCAF

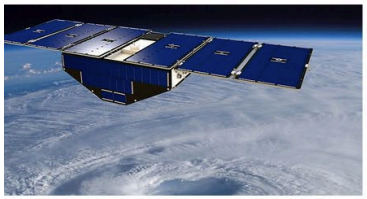
- IUCAF
  - http://www.iucaf.org/Documents/spectrum_management_documentation.htm
- Dark & Quiet Skies II update
- WRC-23 Agenda Items as they progressed

International Science Council charters IUCAF

The International Science Council (ISC) is a non-governmental organization with a unique global membership that brings together over 200 international scientific unions and associations as well as national and regional scientific organizations including academies and research councils.

- Action Plan 2022-2024
- COVID-19 Actions
- Freedoms and Responsibilities in Science
- Transform 21
- Funding Science for Global Sustainability
- ISC at the United Nations
- **Affiliated Bodies**
- Funding Programmes

Thematic Organizations



Committee on Space Research (COSPAR)
The Committee on Space Research (COSPAR) is an interdisciplinary scientific body concerned with the progress on an international scale of all kinds of scientific investigations carried out with space vehicles, rockets and balloons.

Global Research Programme on Inequality (GRIP)
GRIP views inequality as both a fundamental challenge to human well-being and as an impediment to achieving the ambitions of the 2030 Agenda and aims to foster co-designed processes of knowledge creation to understand the multiple dimensions of rising inequalities.

Future Earth
A global network of scientists, researchers, and innovators collaborating to provide the knowledge needed to support transformations towards sustainabili for a more sustainable planet, with the mission to accelerate transformations to global sustainability through research and innovation.

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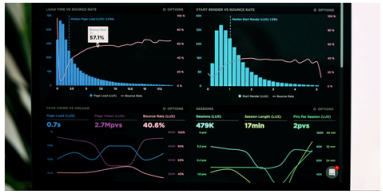
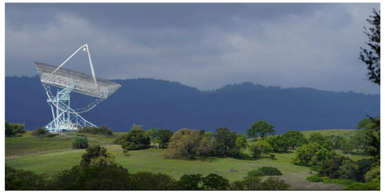




Data and Information

Committee on Data (CODATA)
The CODATA helps realise the ISC's vision of advancing science as a global public good by promoting international collaboration to advance open science and to improve the availability and usability of data for all areas of research.

Frequencies for Radio Astronomy & Space Science (IUCAF)
The IUCAF is an international committee that works in the field of spectrum management on behalf of the passive radio sciences, like radio astronomy, remote sensing, space research, and meteorological remote sensing.

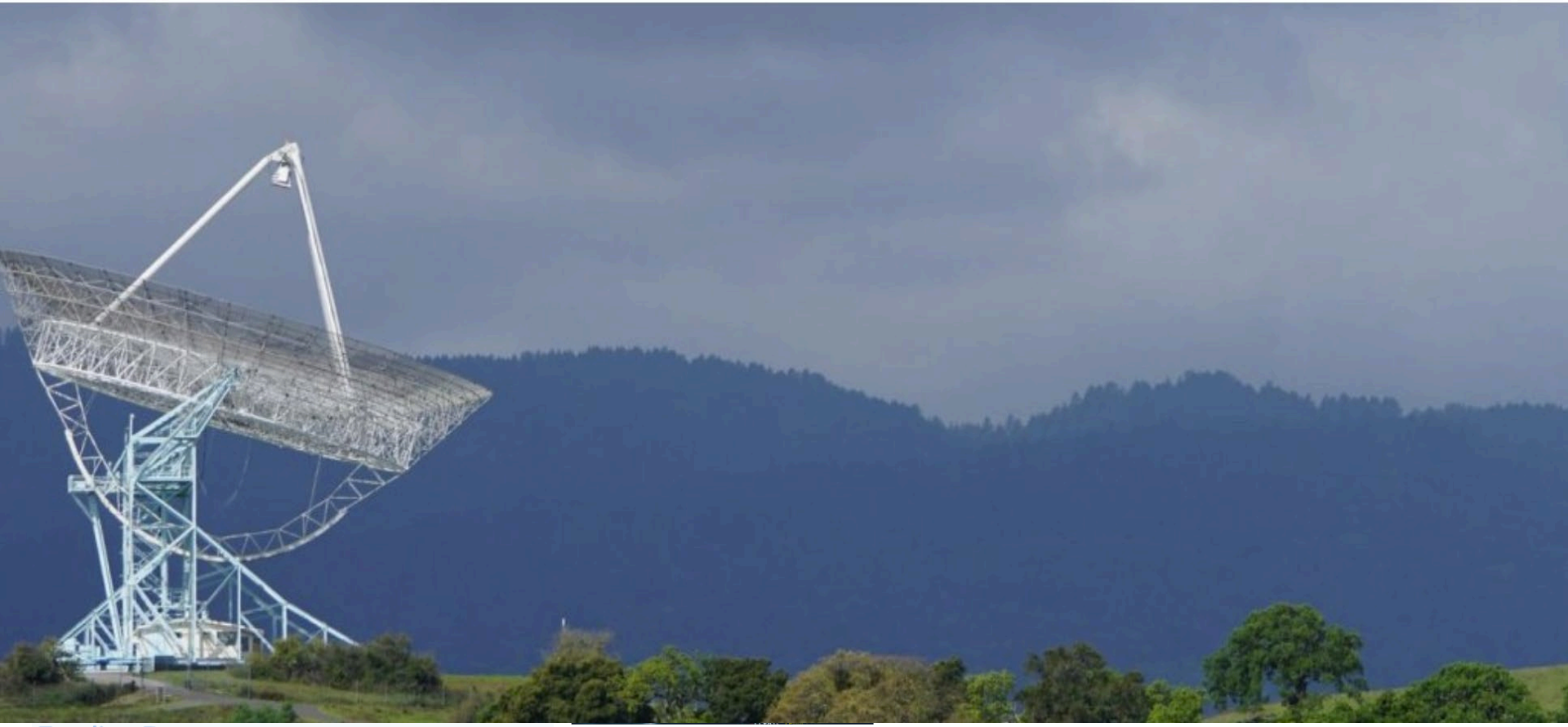
World Data System (WDS)
The WDS's mission is to support the ISC's vision by promoting long-term stewardship of, and universal and equitable access to, quality-assured scientific data and data services, products, and information across all disciplines in the Natural and Social Sciences, and the Humanities.

Affiliated Bodies

★ The ISC and IUCAF

Considering that for research in radio astronomy and space science it is essential to have the use of adequate frequency bands that are sufficiently protected from interference with scientific observations, the ISC's predecessor organization ICSU established, under URSI as Parent Union, an Inter-Union Commission between URSI and IAU in conjunction with COSPAR.

The ISC is in charge of reviewing IUCAF, defining review terms of reference, appointing review panel members, funding and science officers



Funding Programmes

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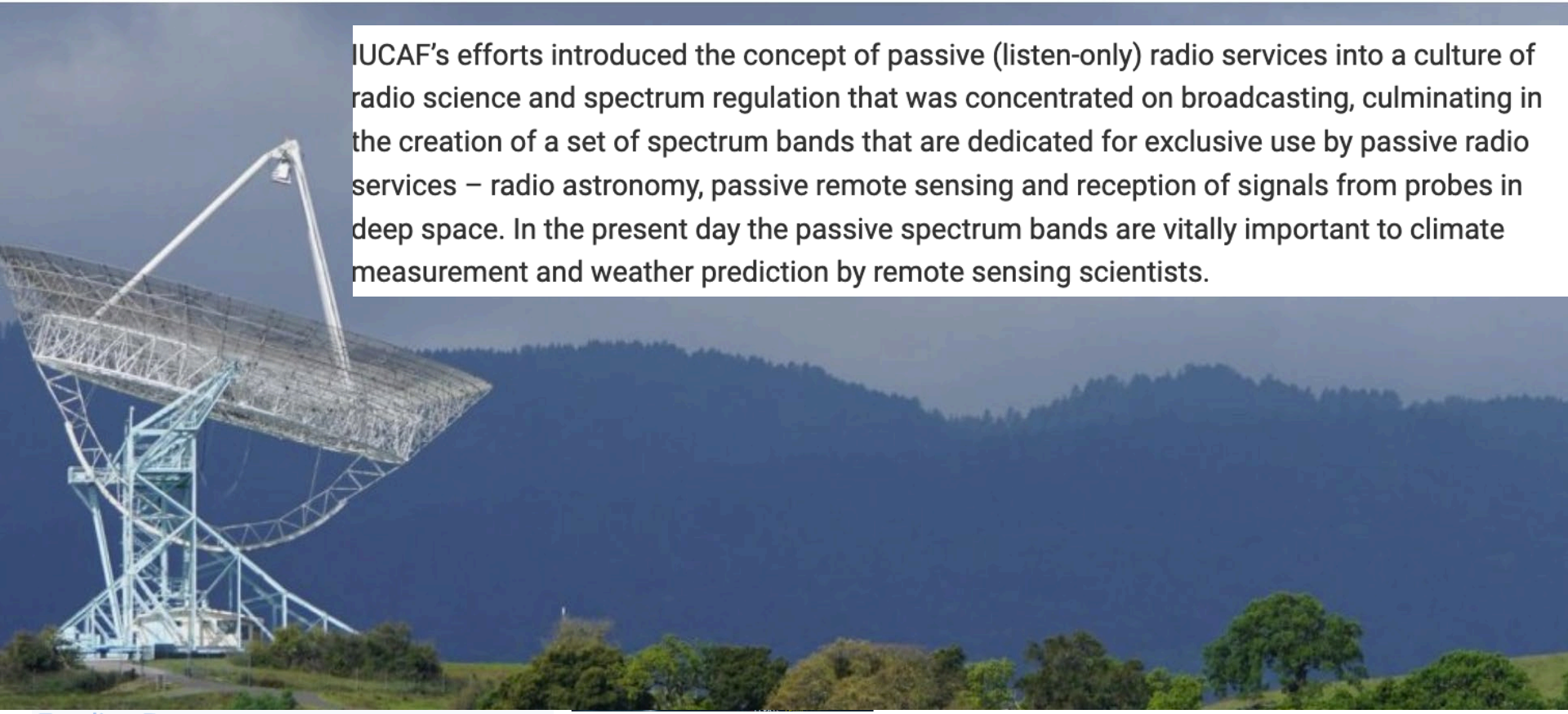

IUCAF's efforts introduced the concept of passive (listen-only) radio services into a culture of radio science and spectrum regulation that was concentrated on broadcasting, culminating in the creation of a set of spectrum bands that are dedicated for exclusive use by passive radio services – radio astronomy, passive remote sensing and reception of signals from probes in deep space. In the present day the passive spectrum bands are vitally important to climate measurement and weather prediction by remote sensing scientists.

Funding Programmes

Affiliated Bodies

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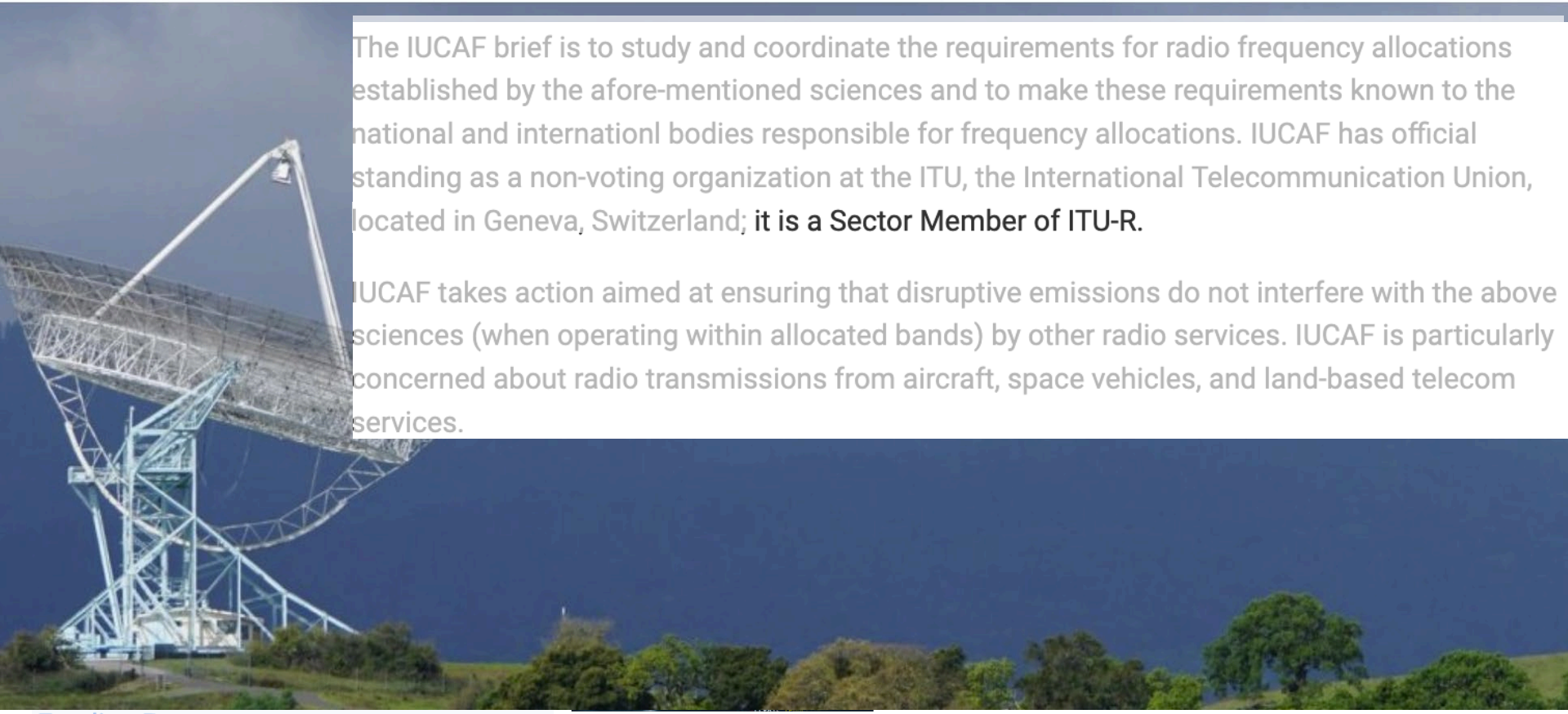


The IUCAF brief is to study and coordinate the requirements for radio frequency allocations established by the afore-mentioned sciences and to make these requirements known to the national and internationl bodies responsible for frequency allocations. IUCAF has official standing as a non-voting organization at the ITU, the International Telecommunication Union, located in Geneva, Switzerland; it is a Sector Member of ITU-R.

IUCAF takes action aimed at ensuring that disruptive emissions do not interfere with the above sciences (when operating within allocated bands) by other radio services. IUCAF is particularly concerned about radio transmissions from aircraft, space vehicles, and land-based telecom services.

Funding Programmes

IUCAF Chairs 1960 - now

Figure 1 The six chairmen of IUCAF. *Top*: J-F. Denisse (1960–1964), F.G. Smith (1964–1975). *Middle*: J.P. Hagen (1975–1981), J.W. Findlay (1981–1987). *Bottom*: B.J. Robinson (1987–1995), W.A. Baan (1995–1999). In March 1999 Klaus Ruf became chairman.

Darrel Emerson 2000-2002

Masatoshi Ohishi 2009-2015

Wim van Driel 2003-2009

Harvey Liszt 2015-

Figure 1 The six chairmen of IUCAF. *Top*: J-F. Denisse (1960–1964), F.G. Smith (1964–1975). *Middle*: J.P. Hagen (1975–1981), J.W. Findlay (1981–1987). *Bottom*: B.J. Robinson (1987–1995), W.A. Baan (1995–1999). In March 1999, Klaus Ruf became chairman.

Some history

Organized by T. Gergely

I.U.C.A.F AND FREQUENCIES FOR RADIO ASTRONOMY

JOHN W. FINDLAY
Senior Scientist at the National Radio Astronomy Observatory until retirement in 1985

International Astronomical Union Colloquium No. 112 Page 195

https://tinyurl.com/sygkq7c

More history

Figure 1 The six chairmen of IUCAF. *Top*: J-F. Denisse (1960–1964), F.G. Smith (1964–1975). *Middle*: J.P. Hagen (1975–1981), J.W. Findlay (1981–1987). *Bottom*: B.J. Robinson (1987–1995), W.A. Baan (1995–1999). In March 1999, Klaus Ruf became chairman.

Annu. Rev. Astron. Astrophys. 1999. 37:65–96

FREQUENCY ALLOCATION: The First Forty Years

Brian Robinson
Research Fellow Emeritus, Australia Telescope National Facility, Epping, N.S.W. 2121 Australia; e-mail: brobinso@ozemail.com.au

Key Words Frequency management, IUCAF, world radio conferences, radio interference, mobile satellites, radio astronomy

■ **Abstract** In 1960 ICSU set up an Inter-Union Commission (IUCAF) on the Allocation of Frequencies for Space Research and Radio Astronomy, to keep key parts of the radio spectrum clear for passive, scientific use. IUCAF represents URSI, IAU and COSPAR at World Radio Conferences (WRCs) convened by the International Telecommunications Union (ITU) in Geneva; the WRCs establish the international law which governs users of the radio spectrum. This review recounts many serious threats posed to passive scientific research by commercial and military operations, particularly those involving radio emissions from aircraft and spacecraft. The continual conflict between commercial greed and scientific curiosity has often put the future of radio astronomy, space research, and earth exploration in jeopardy. The conflict increases as we move into the Information Age.

https://tinyurl.com/yxyheela

Some topics from D&Q Skies II

- IUCAF
- Dark & Quiet Skies II update
- WRC-23 Agenda Items as they progress

Why Satcon1,2 + Dark&Quiet Skies?

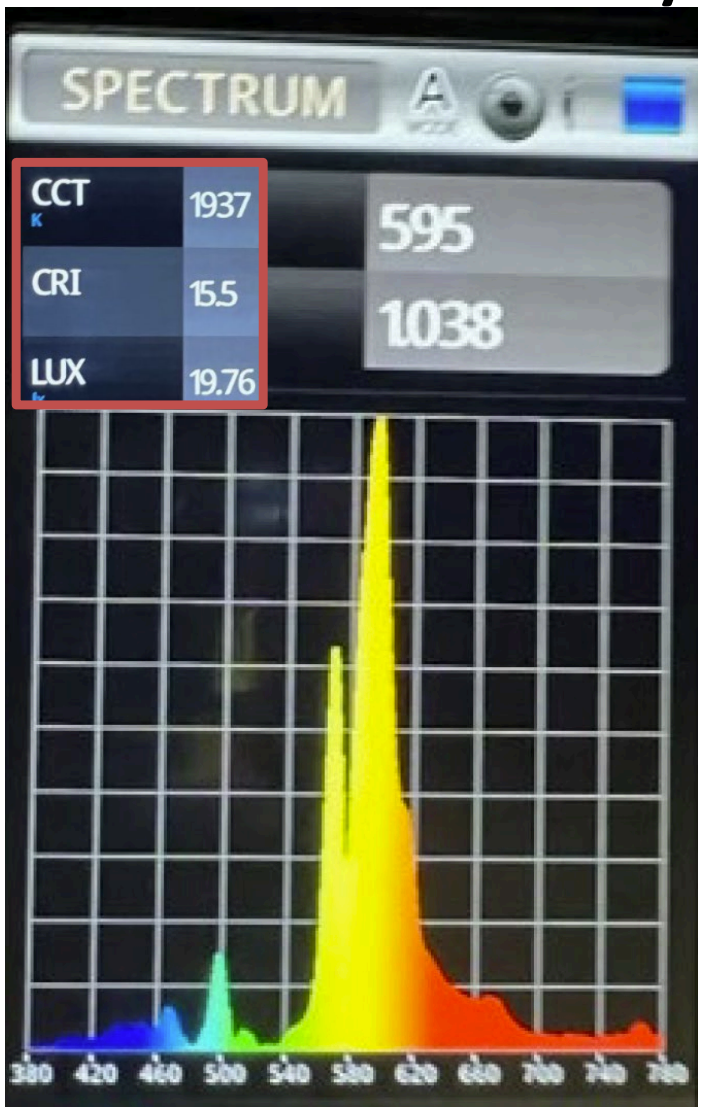
- Convergence of concerns among astronomers
  - Before 2019, little in common, OIR & Radio
    - US OIR astronomers concerned with locally-regulated light pollution (LP) and proliferation of LED lighting
      - Only the most loosely-organized response to light pollution
      - LP part of national environment regulation in other countries
    - Radio astronomy subject to national, international spectrum regulation
      - Radio astronomy arose out of radio communications
      - Had its epiphany with satellite interference 40+ years ago

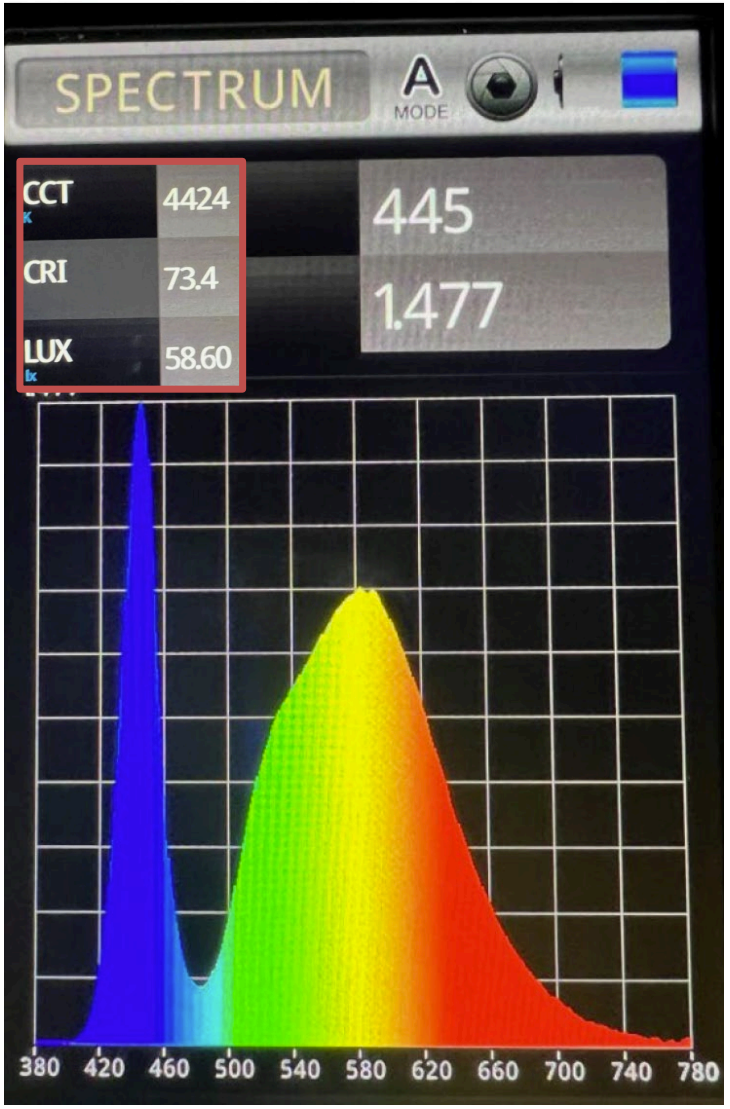
IUCAF Radio Astronomy Space Science iucaf.org

Courtesy of Ashley Pipkin, National Park Service Natural Sounds and Night Skies Division Biologist Unified Regions 8,9,10,12
and the AAS Executive Committee on Light Pollution, Radio Interference and Space Debris

Optical astronomy concerns until 2019

Old HPS





New LED

And then, overnight, this

SatCon 1 https://aas.org/satellite-constellations-1-workshop

The dark sky threatens to become a nightly circus of artificial illumination

EXTREMETECH

Absence of protection for the sky and optical astronomy, and inadequacy of radio spectrum regulation to provide access to spectrum for science, have moved the discussion in new directions

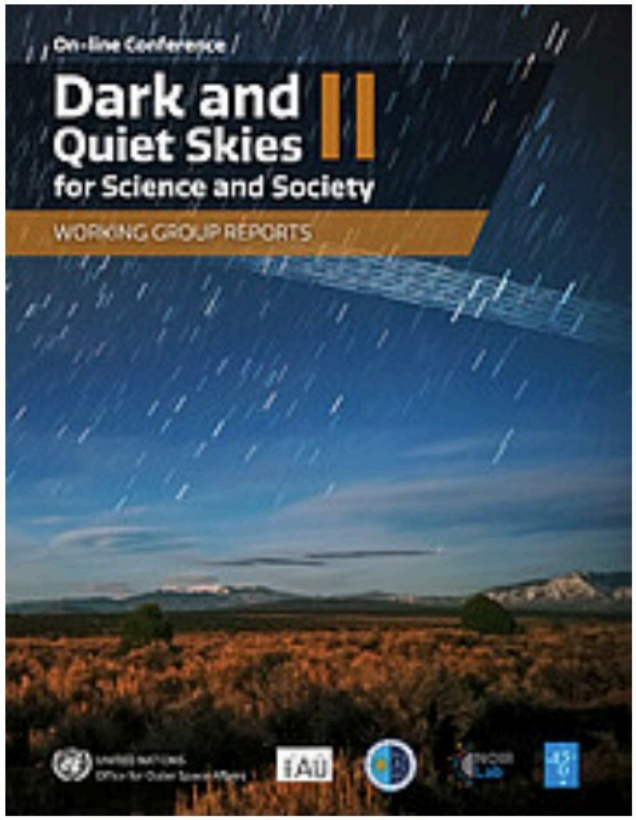
Sponsored by UNOOSA, IAU, CIE, IAC

*"Two things fill the mind ...: **the starry heavens above me and the moral law within me.**"*

Immanuel Kant, Critique of Practical Reason

http://research.iac.es/congreso/quietdarksky2021/

Dark & Quiet Skies II produced documents & recommendations for UNOOSA COPUOS



https://www.iau.org/news/announcements/detail/ann22002/

https://www.iau.org/static/science/scientific_bodies/working_groups/286/dark-quiet-skies-2-working-groups-reports.pdf

Three Working Groups

Table of Contents

Radio Astronomy Working Group

Chair:

Di Vruno	Federico	Square Kilometre Array Observatory	UK

Original Co-Chairs:

Liszt	Harvey	NRAO and Chair of The Scientific Committee on the Allocation of Frequencies for Radio Astronomy and Space Science	USA
Ohishi	Masatoshi	National Astronomical Observatory of Japan	JPN

Members:

De Pree	Christopher	National Radio Astronomy Observatory (NRAO)	USA
Gergely	Tomas	Retired	USA
Hellbourg	Greg	California Institute of Technology	USA
Indermuehle	Balthasar	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	AUS
Lindqvist	Michael	Chalmers and Chair of The Committee on Radio Astronomy	SWE
Tzioumis	Anastasios	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	AUS
Vanderley	Bevin Ashley	National Science Foundation (NSF)	USA
Winkel	Benjamin	Max Planck Institut für Radioastronomie (MPIfR)	DE
Zhang	Haiyan	National Astronomical Observatories, Chinese Academy of Sciences	CHN

Radio Astronomy Working Group

Radio Astronomy Working Group

The following two recommendations distill the discussion and the experience of radio astronomers and radio astronomy spectrum managers into two practical tools that are needed to allow radio astronomy to continue to operate:

- **RAS1**: Non-GSO satellites should be required to be able to avoid direct illumination of radio telescopes and radio quiet zones, especially the radar and other high-power satellite applications that are capable of burning out radio astronomy's receivers;
- **RAS2**: Non-GSO satellites should be required to have sidelobe levels that are low enough that their indirect illuminations of radio telescopes and radio quiet zones do not interfere, individually or in the aggregate.

Radio Astronomy Working Group

From IUCAF's 2021 talk

ars TECHNICA BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE STO

NO D[illegible]S FOR ME —

NASA objects to new mega-constellation, citing risk of "catastrophic collision"

"This particular region of space tends to produce a large number of conjunctions."

ERIC BERGER - 11/2/2020, 6:30 PM

Enlarge / Sixty Starlink Internet communication satellites from SpaceX are seen in the night sky over Vladivostok.

AST&Science aka AST SpaceMobile

AST&Science aka AST SpaceMobile asked FCC to license 247 Papua-New Guinean satellites of area 500 – 1000 m^2 each

One SpaceX satellite is 5 m^2

AST satellites would communicate directly with cell phones

Radio regs forbid direct communication between space and ground for devices using mobile service frequency allocations

AST registered at ITU-R as a conventional FSS or MSS constellation

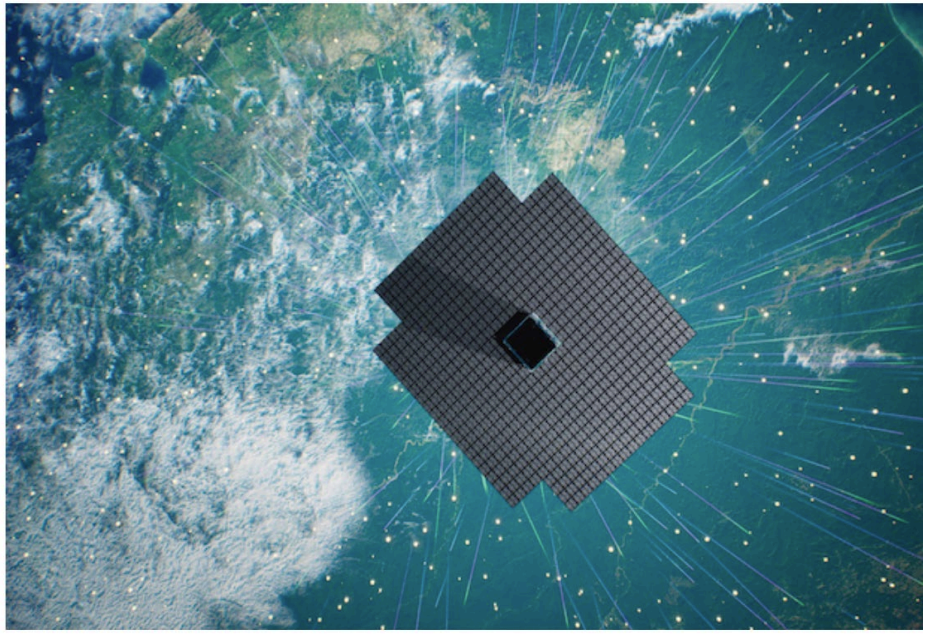
Use of mobile service frequencies was not noted in their ITU-R registration

FCC Responded in Early May 2022

FCC Grants AST SpaceMobile Experimental License

By Rachel Jewett | May 3, 2022

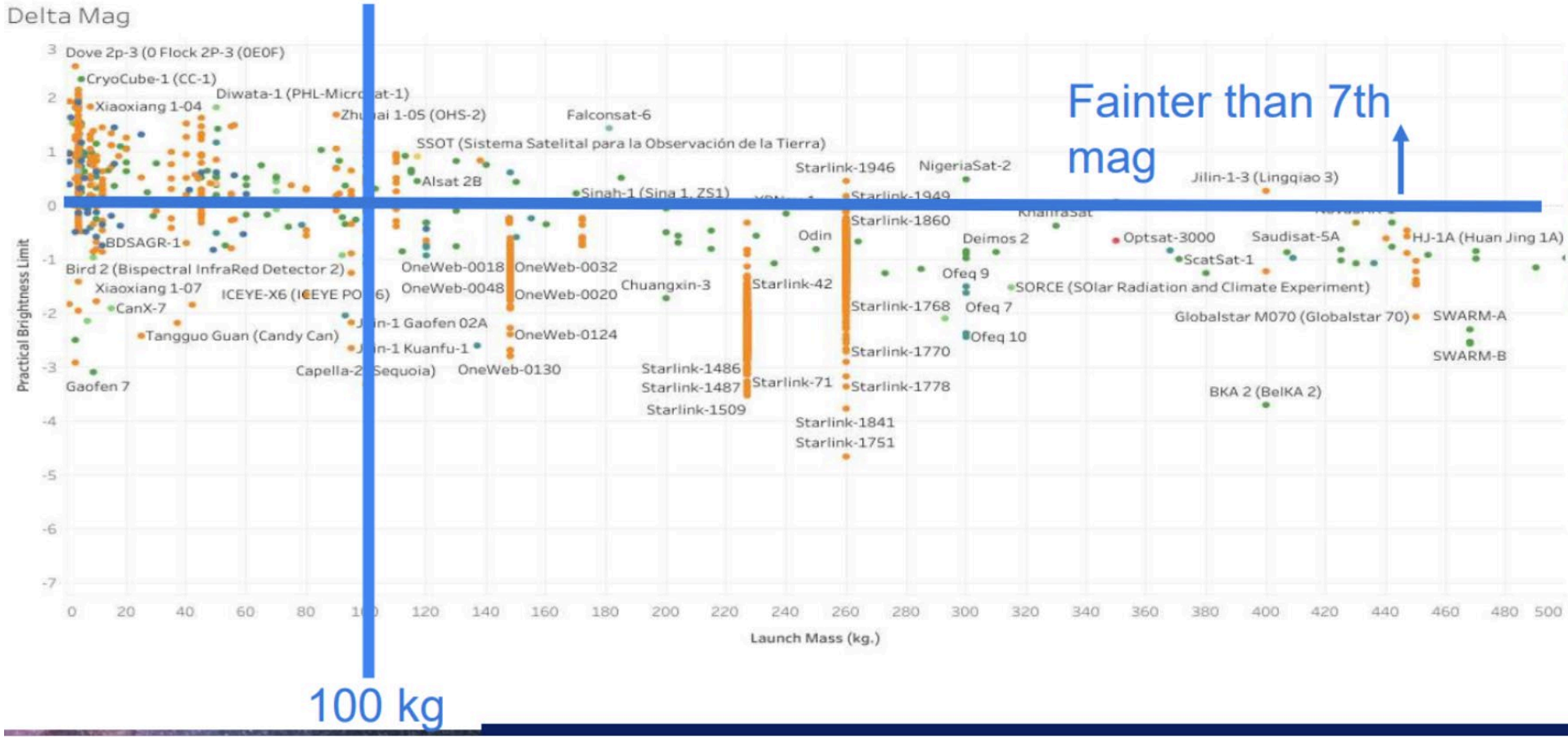
Government



Rendering of an AST SpaceMobile satellite. Photo: AST SpaceMobile

So what's to worry about?

- Moots protections of radio quiet zones
- Satellites will be extremely optically bright



Resources

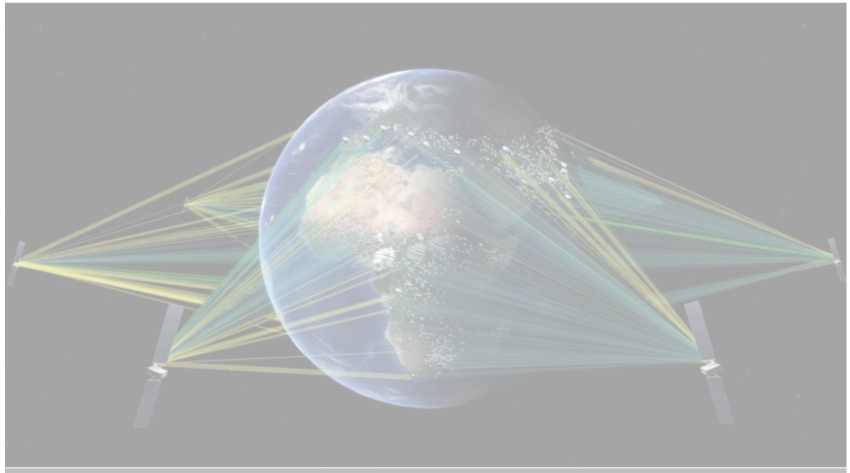
- Plot of brightness vs mass: D&QS II and https://public.tableau.com/app/profile/therese.jones/viz/DeltaMagvsmass/DeltaMag

- Experimental license applications (original/revised) & grant:
  - https://apps.fcc.gov/oetcf/els/reports/GetApplicationInfo.cfm?id_file_num=1059-EX-CN-202
- NRAO's filings laying out the opposing case against AST and Lynk:
  - https://licensing.fcc.gov/myibfs/download.do?attachment_key=2862535
  - https://licensing.fcc.gov/myibfs/download.do?attachment_key=9507364

SES is considering plans to provide 5G services directly to handheld devices after rescuing spectrum rights for a constellation. Luxembourg's government filed an application in 2015 to international regulators at the ITU for the constellation, dubbed Cleosat, but faced losing it until SES used at least one of its satellites to secure the frequencies May 10, two days before the deadline. SES said its interest in the constellation is because of the "potential of direct-to-handheld 5G satellite connectivity in the years to come," but has not disclosed additional details or a schedule for the system. The proposed Cleosat constellation uses multiple frequency bands from around 1.5 to 29 gigahertz, covering 62 satellites across eight planes in non-geostationary orbits between 519 and 8,062 kilometers. [SpaceNews]

SES mulls direct-to-handheld 5G satellite business

by Jason Rainbow — May 12, 2022



Artist's rendition of the O3b mPower constellation, SES's next-generation MEO constellation. Credit: SES.

Radio Astronomy Working Group

- Fringe idea? With $100,000,000 x n behind it?
  - https://www.caltech.edu/about/news/caltech-announces-breakthrough-100-million-gift-to-fund-space-based-solar-power-project
  - https://spacenews.com/afrl-and-northrop-grumman-test-key-hardware-for-space-based-solar-power-experiment/
- Resources for solar power satellites
  - Thompson, A. R. 1981, Radio Science, 16, 35
  - References at https://www.cv.nrao.edu/~hliszt/RFI/SolarPower-SPS/
  - Optical appearance Horiuchi, H. and Ohishi, M. 2020, ApJ, 905, 3
    - https://ui.adsabs.harvard.edu/abs/2020ApJ...905....3H/abstract

Radio Astronomy Working Group

WRC-23 in the Emirates

- IUCAF
- Dark & Quiet Skies II update
- WRC-23 Agenda Items as they progress

WRC-23 Agenda Items

- If there's a theme, it's not satellites but about taking terrestrial allocations aloft … remember that everything that is not a space station or a radio astronomy station is an earth (terrestrial) station

WRC-23 Agenda Items

- AI 1.2 IMT at 6 425-7 025 MHz (Region 1)
  - Counter-argument, consideration of 6.7 GHz methanol maser line out of scope owing to lack of allocation
- AI 1.2 IMT at 10 - 10.5 GHz (Region 2)
  - Incompatible with EESS (active) X-band SAR at 10-10.4 GHz, emailed Capella Space asking if they care
  - EESS (passive) at 10.6 – 10.7 GHz needs spurious emission limits ~10+ dB below spec of -30 dBm/MHz (US) or ~10 dB added vertical sidelobe suppression of base station antenna pattern (Brasil)
  - No studies yet for RAS at 10.6 – 10.7 GHz but soon

WRC-23 Agenda Items

- AI 1.4 HIBS = IMT base stations on HAPS
  - IUCAF/CRAF/SKA study and Brazil study show incompatibility in LOS at 2 690 – 2 700 MHz
  - CRAF/SKA study at 1 610-1 613.8 MHz wrt 2nd harmonic of HIBS operating at 694-960 MHz is contentious
- AI 1.6 IMT Sub-orbital vehicles
  - Operators just want to continue their present practice equipping SOV with terrestrial and space avionics and using them interchangeably

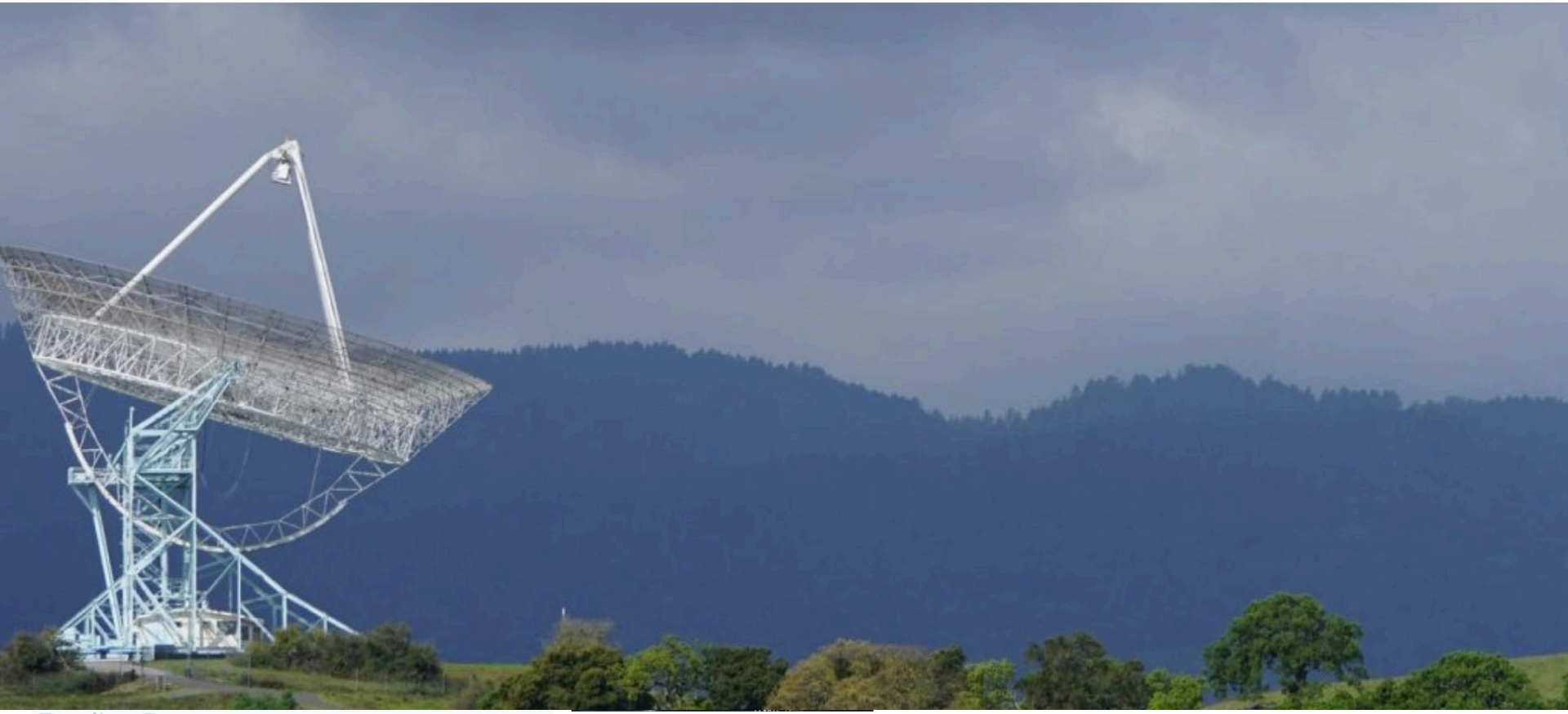
WRC-23 Agenda Items

- AI 1.8 accommodate use of fixed-satellite service networks by control and non-payload communications of unmanned aircraft
  - A nightmare, dragging on since 2007
- AI 1.10 non-safety aircraft mobile service
  - Like Aeronet 70/80/90 GHz proceeding in US, but at 15.4 – 15.7 and 22.21 – 22.5 GHz
  - WRC-12 was told this could never happen if a radio-location allocation was extended down to 15.4
  - Extreme pressure on 15.35 – 15.4 GHz 5.340 band
  - IUCAF study shows obvious hazards without simulating the entire system

WRC-23 Agenda Items

- 1.12 new secondary allocation to EESS (active) for spaceborne radar sounders around 45 MHz
  - OK as long as not used in the SZM
- 1.13 Upgrade SRS to primary at 14.8-15.35 GHz for space data relay satellites
  - Curious lack of compatibility study with RAS at WP 7B
  - Characteristics not published to allow RAS to study
- 1.14 Realignment of EESS (passive) just above 235 GHz to accommodate where sensors work
  - Getting pushback from US over burden on FS

Thanks for inviting me



Funding Programmes

Thanks for inviting me

Funding Programmes

IUCAF for CORF

The morning of November 16, 1988, and the 300-foot telescope is a collapsed ruin.